Effects of the Anisotropy in Charge Carrier Drift Velocity on Position-Sensitive Germanium Detectors

A. Kuhn, K. Vetter, I.Y. Lee

One of the most pressing issues in the GRETA development is the study of signal processing methods and to understand factors which effect pulse shapes in segmented germanium detectors. We have examined the effect of the anisotropy in charge carrier drift velocity (with respect to the orientation of the crystallographic directions) on the determination of γ-ray interaction positions. Measurements were made to study the effect for both the holes and electrons in (closed-ended coaxial) germanium detectors.

In order to study the effect of the anisotropy in drift velocity, a series of measurements were made using collimated γ-ray sources of ^{137}Cs and ^{241}Am and both n- and p-type high-purity germanium detectors. Signals in the coaxial region of the detector were obtained from several angular positions (r,θ locations) relative the center line of the crystal. The radius r of the interaction location was held constant and only the angle θ was varied. Figure 1 shows a cross-section the detector crystal and the relative locations of the interaction positions.

The drift time was obtained from the length of the signal for each angular position. Due to the fact that the interaction was located at a large radius, the duration of the current signal was determined by the electrons in the n-type detector and the holes in the p-type detector. Since r was constant in each of the measurements, the variation in the duration of the current signal is due mainly to the anisotropy in drift velocity of the charge carriers with respect to the crystallographic axes. The duration of the current signals for one of the measurements can be seen in Figure 2.

For the electrons, in the n-type detector, the measured drift time variation is approximately 8%. For the holes in the p-type detector, the variation was measured to be approximately 13%. If uncorrected, this can lead to an error in the radial position of an interaction of up to 2.5 mm for a drift distance of 2 cm. These results show, for the γ-ray tracking in GRETA, this effect must be taken into account to obtain the desired position resolution of about 1 mm [1].

In addition, we have also studied the variation in the drift direction with respect to the direction of the applied electric field.

Footnotes and References

1. K.Vetter et al., Submitted to NIM (2000)

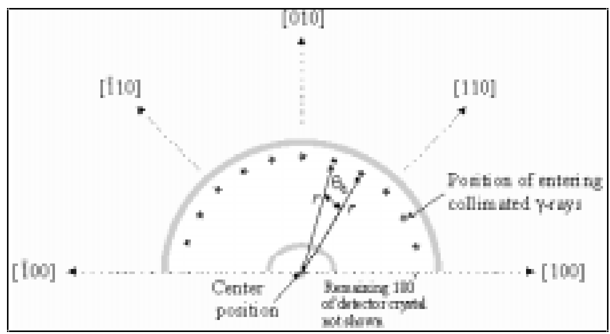

Fig. 1. Cross-section view of the coaxial region of the detector. The stars indicate the location of the entering collimated γ-rays.

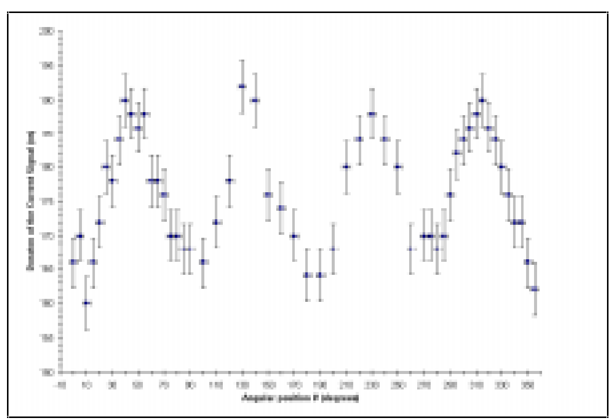

Fig. 2. Shows the duration of the current signals as a function of angle for the holes in the p-type detector (^{137}Cs measurements).